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ANHYDREMIA IN APPENDICITIS

ADEQUATE preparation of seriously ill surgical patients before operative intervention is receiving greater stress, but objective measurements of what constitutes adequate fluid therapy are almost completely lacking. Postoperative administration of fluids also remains largely on an empirical basis in spite of much excellent work.[2, 4, 5, 6, 8, 9, 10, 16]

As an aid in determining the state of hydration, we have found a series of simple tests of great service. They are: (*a*) determination of the specific gravity of the whole blood;[7] (*b*) a reading of the relative percentage of cells and plasma in venous blood by means of an hematocrit; (*c*) determination of the specific gravity of the plasma and (*d*) its translation into plasma protein by a simple formula. The whole procedure can be done by a person with a minimum of technical training within one-half hour and considering the little labor and time required gives a large amount of useful information.

A simplified method of weighing a drop of blood was reported by Roy[13] in 1884. Rogers[12] made use of this both in measuring anhydremia in the dehydrated cholera case and in *controlling* the large amounts of fluid which were necessary to rehydrate them. The result of this controlled therapy was a 30 per cent decrease in the cholera mortality at Calcutta General Hospital.[15]

Forty years later, Barbour and Hamilton[3] introduced a

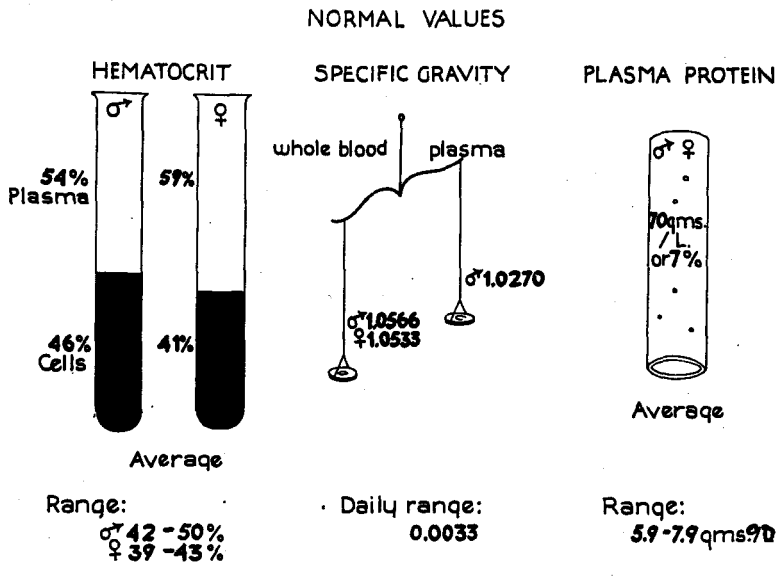

Fig. 104.

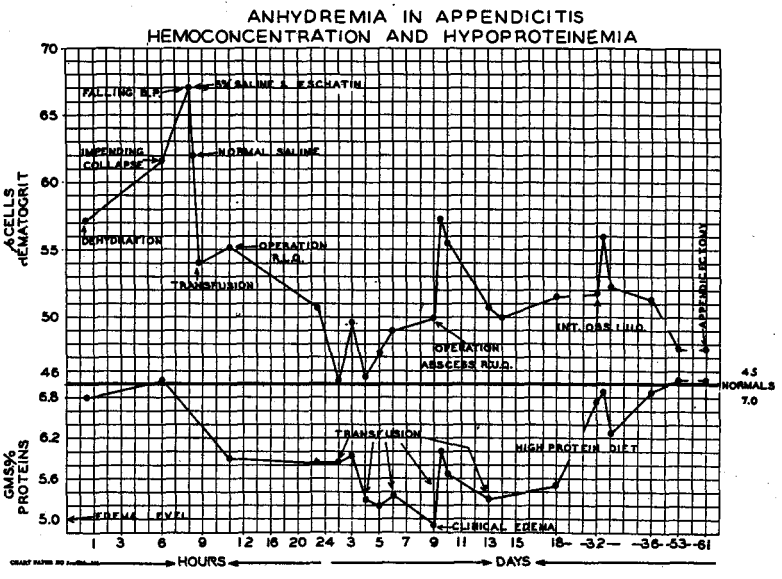

Fig. 105.—Shows the great difficulty in administering sufficient fluids to overcome dehydration and at the same time prevent the proteins from sinking below the edema level. It demonstrates clearly the rapid effect of blood transfusion on cell volume but poor effect on proteins.

convenient, quick method of determining the specific gravity of body fluids. It is this method which we use for our specific gravity determinations. The results are accurate to the fourth decimal place and are translatable into terms of hemoglobin percentage, hematocrit and red cell count.

The second test is determining the cell volume in venous blood. The sample is spun in a Sanford-Magath[14] hematocrit tube at 3000 r. p. m. for one hour to secure complete packing. In acute cases where information is urgently needed centrifuging for fifteen minutes is sufficient. For clinical purposes the difference in the readings is insignificant.

The fourth test is built on the observation of Moore and Van Slyke[11] that there is a constant relationship between serum or plasma specific gravity and the protein level. Weech, Reeves, and Goettsch[17] retested this finding on dogs and expressed the relationship as a simple equation. It is this formula which we have reverified for human blood and use routinely. Changes in plasma proteins give a very real picture of the degree of blood dilution or concentration as previously suggested by Atchley and Benedict.[1] The ability to get this information in fifteen minutes if necessary, we find invaluable.

Rather than report a series of cases at this time, it is felt that the presentation of one in detail would be helpful in demonstrating the method and the rationale of the therapy.

Normal Values

(Fig. 104)

1. Blood specific gravity	
Male	1.0566
Female	1.0533
Daily range	0.0033
2. Hematocrit	
Male	42.0–50.0 per cent cells
Female	39.0–43.0 per cent cells
3. Plasma specific gravity	
Male and female	1.0260–1.0280
4. Plasma proteins	
Male and female	7.0 Gm. per cent
Range	5.9–7.9 Gm. per cent

Perhaps an easier group of values to remember and to strive for in sick surgical patients as well as being of more practical value is the following:

1. Blood specific gravity 1.0550
2. Hematocrit
   - Needs blood when below..... 35.0 per cent cells
   - Needs fluid when above..... 50.0 per cent cells
   - This must always be interpreted in relation to protein level.
3. Plasma specific gravity 1.0265
4. Plasma proteins
   - Suspect hemoconcentration when above ..... 7.0 Gm. per cent
   - Latent edema level below..... 5.5 Gm. per cent
   - Patent edema level below..... 5.0 Gm. per cent
   - (There is no rapid method of determining A-G ratio)

Case Report: P.H. No. 563298. A. W., white male, aged seventeen, was admitted to surgical wards at 11.45 A.M., October 21, 1938.

Chief Complaint: Severe abdominal pain of six days' duration.

Family and Past History: Irrelevant.

Present Illness: Began with vague epigastric pain on the evening of October 16th. For this he took half a bottle of magnesium citrate and went to bed. At 7 A.M. the next morning he was awakened by severe abdominal cramps. He attempted breakfast a little later, but vomited at once. A physician was called who considered the condition one of "intestinal flu," prescribed alkali powders, fruit juices, an enema and heat to the abdomen. The next day the temperature was 102° F., the abdominal pain, nausea and vomiting had persisted with tenderness in the lower right quadrant. The third day he felt better but on the fourth, the patient became conscious of what he thought was a mass in his rectum which caused very frequent stools. On the sixth day be became so much worse that his parents brought him to the hospital. His nausea, vomiting, diarrhea, abdominal pain and tenderness had continued since the second day of his illness.

Physical Examination: Showed severely ill boy, markedly dehydrated and in poor state of nutrition. Temperature 103° F.; pulse 110; respirations 28; blood pressure 126/70. Lips parched and cracked, sordes on gums, tongue coated and dry. Chest clear. Heart normal in size, rhythm regular, no adventitious sounds. Abdomen: Rigid; slightly distended; tender throughout; quiet; flanks dull suggesting fluid. No masses felt. Rectal examination revealed boggy tender mass in right lower quadrant.

Laboratory Data: White blood corpuscles 5000, polymorphonuclears 83 per cent, lymphocytes 17 per cent. CO_2, 61 volumes per cent. Serum chlorides, 545 mg. per cent.

Roentgen Ray: "No gas but possible fluid in peritoneal cavity."

Impression: Generalized peritonitis, probably due to ruptured appendix and incomplete localization of abscess.

12.30 P. M.: First emergency blood studies.

Hematocrit	57.1 per cent cells
Plasma specific gravity	1.0269
Plasma protein	6.8 Gm. per cent

1.00 P. M.: Interpretation of studies.

"The hematocrit shows marked hemoconcentration, equivalent to about 20 per cent rise in hemoglobin, and 1,000,000 rise in red blood cells.

"Plasma specific gravity, contrary to the rise seen in simple dehydration, was within normal range; but, when considered in relation to high cell volume indicates a loss of proteins."

In this case it was interpreted to mean a loss of proteins into the peritoneal cavity either from a ruptured viscus or as the result of peritoneal irritation.

To restore fluid balance, before any other procedures were contemplated, 3000 cc. of 5 per cent glucose in normal saline was given by infusion.

6.45 P. M.: Second blood studies after the fluid had been administered showed:

Hematocrit	61.6 per cent cells
Plasma specific gravity	1.0279
Plasma proteins	7.14 Gm. per cent

7.45 P. M.: The interpretation of these findings was as follows:

"This patient shows a greater degree of dehydration and hemoconcentration now than he did *before the administration* of fluid; he is definitely sicker; *the fluid has not been utilized.* This is a *preshock picture,* always of ill omen, and measures to break up the peripheral arteriolar and venular constriction, to restore tone to the paralyzed capillaries, and to increase the volume of circulating fluid should be taken at once."

"SUGGESTIONS:

1. 300 cc. of 5 per cent sodium chloride to assist in restoring circulation by
   (*a*) increasing the blood volume,
   (*b*) decreasing the viscosity and increasing volume flow and
   (*c*) relaxing spasm of the arterioles and venules.

2. 20 cc. of eschatin (suprarenal cortical hormone) in the saline infusion to
   (*a*) restore capillary tone,
   (*b*) improve kidney function,
   (*c*) redistribute fluids and electrolytes, and
   (*d*) raise blood pressure.
3. 1000 cc. of normal saline to further decrease hemoconcentration and restore tissue fluids.
4. 500 cc. blood transfusion to sustain circulatory volume."

8.00 P. M.: Boy very drowsy, no longer complains of pain; temperature 104° F.; pulse 130; respirations 30; blood pressure 100/60 (it is of interest that the systolic pressure has fallen 26 mm. Hg).

8.10 P. M.: Whole blood specific gravity before start of therapy: 1.0639.

Equivalent to:	R. B. C.	6,390,000
	Hb.	135 per cent
	Hematocrit	67.0 per cent

This inspissation of peripheral blood further substantiates impending collapse.

An infusion of 300 cc. of 5 per cent sodium chloride and 20 cc. of eschatin was given at this time.

8.25 P. M.: Whole blood specific gravity: 1.0611.

"This represents a definite break up of peripheral stasis, but still dehydration is too great."

Blood pressure rose from 100/60 to 160/80 in the fifteen minutes so that it was felt that further eschatin was contraindicated. Likewise, further hypertonic salt solution seemed ill advised because of the definite danger of drawing into circulation intracellular fluid when the extracellular fluids are low.

8.30 P. M.: 800 cc. of normal saline given rapidly, intravenously in fifteen minutes.

8.45 P. M.: Hematocrit 54.0 per cent cells. Interpretation:

"This represents a reduction in cell volume of approximately 13 per cent and is the first evidence of success in reducing hemoconcentration."

8.50 P. M.: Transfusion started, direct multiple syringe method.
9.00 P. M.: Transfusion finished, 500 cc. Blood pressure 145/80. Continuous infusion of normal saline with 10 cc. of eschatin (250 dog units) for each 1000 cc. at rate of 200 cc. an hour.

11.00 P. M.: Hematocrit ..... 55.0 per cent cells
Plasma specific gravity 1.0243
Plasma protein ..... 5.92 Gm. per cent

It was felt that if operative interference was contemplated the patient was sufficiently prepared. The question of whether to operate or wait centered around the question of the ability of the peritoneum to handle the infected material. It was decided that even in the face of an acute diffuse spreading peritonitis, a drain down to the region of the appendicular abscess was indicated.

12.00 Midnight: Operation.

Under local anesthesia a McBurney incision was made and with as little disturbance as possible several large pockets of pus were aspirated, the largest pointing down into the pelvis. No exploration was attempted. Neither the appendix nor any necrotic tissue was seen, only a diffuse peritonitis of the fibrinopurulent type with multiple abscess formation. A soft rubber tube and silk tampon to hold the wound edges apart were inserted. Culture: Bacillus coli.

Patient returned to ward; continuous infusion regulated to 200 cc. an hour and Abbott tube introduced to prevent distention and paralytic ileus.

Total fluid first twenty-four hours: Intake 5700 cc., output 800 cc. (excluding insensible water loss).

October 22.—Temperature 103° F.; pulse 100; blood pressure 115/70 well sustained. White blood corpuscles 12,000.

11.00 A. M.: Hematocrit ..... 50.9 per cent cells
Plasma specific gravity 1.0241
Plasma protein ..... 5.85 Gm. per cent

This was considered as an excellent response to therapy but blood is still concentrated. Patient still very ill.

Total fluid in twenty-four hours: Intake 9100 cc., output 4000 cc. including a 1300 cc. drainage from wound.

October 23.

Hematocrit	45.3 per cent cells
Plasma specific gravity	1.0241
Plasma protein	5.85 Gm. per cent

"A better picture in every respect except that proteins are low." As low proteins lead to wet tissues, weak wounds and sluggish peristaltic movements of the gut, a blood transfusion was given. "The problem has now shifted from one of dehydration to one of nutrition and edema level."

Fluid intake 5500 cc., output 3320.

October 24.

Hematocrit	49.8 per cent cells
Plasma specific gravity	1.0244
Plasma protein	5.95 Gm. per cent

Temperature 102° F.; pulse 90; blood pressure 120/60; serum chlorides: 600.

Rectal tube ineffectual in reestablishing normal peristaltic movements. W. B. C. 13,690; Polys, 98 per cent.

Fluid intake 5185 cc., output 2550 cc.

October 25.

Hematocrit	45.7 per cent cells
Plasma specific gravity	1.0225
Plasma proteins	5.31 Gm. per cent

"Proteins are being lost rapidly, a common finding when large abscesses are being formed." *A third transfusion.* All parenteral fluid now in form of 5 per cent glucose in sterile water because of high chlorides. To build up proteins, beef broth, gelatin, and junket were given by mouth.

Fluid intake 4995 cc., output 1790 cc.

October 26.

Hematocrit	47.5 per cent cells
Plasma specific gravity	1.0222
Proteins	5.21 Gm. per cent

Slight distention, definite mass in both right upper and left lower quadrants.

Fluid intake 4200 cc., output 3100 cc.

October 27.

Hematocrit	49.0 per cent cells
Plasma specific gravity	1.0227
Proteins	5.37 Gm. per cent

Slight improvement in fluid picture. W. B. C. 27,000; Polys 81 per cent. Fourth transfusion 300 cc. to assist in raising proteins above 5.50 Gm. per cent which is considered above the latent edema level.

Intake 5460 cc., output 3790 of which 1940 was drainage.

October 30.

10.00 A. M.: Before operation.

Hematocrit	50.0 per cent cells
Plasma specific gravity	1.0214
Plasma proteins	4.93 Gm. per cent

"This shows proteins to be definitely below edema level. Clinically he has developed edema of the ankles, scrotum and back."

11:00 A. M. Operation: Incision and drainage of intraperitoneal subhepatic abscess.

9.00 P. M.: After transfusion and low fluid intake.

Hematocrit	57.4 per cent cells
Plasma specific gravity	1.0247
Plasma proteins	6.05 Gm. per cent

Interpretation: Patient needs more fluids to bring R. B. C. down but not enough to reduce proteins again to edema level.

October 31.

Hematocrit	55.6 per cent cells
Plasma specific gravity	1.0237
Plasma proteins	5.72 Gm. per cent

White blood corpuscles 7000. Edema gone.

November 2.

Hematocrit	50.8 per cent cells
Plasma specific gravity	1.0231
Plasma proteins	5.52 Gm. per cent

Suction discontinued. Pain over left upper quadrant.

November 3.

Hematocrit	50.0 per cent cells
Plasma specific gravity	1.0226
Plasma proteins	5.34 Gm. per cent

"Proteins decreasing. Mass in left upper quadrant. Suggest sixth transfusion of 500 cc. Fluids all right. Force protein food."

November 7.

Hematocrit	51.6 per cent cells
Plasma specific gravity	1.0232
Plasma proteins	5.54 Gm. per cent

Definite mass in left upper quadrant. Question of intestinal obstruction. Abbott tube inserted. Food stopped.

During the next two weeks there were no significant changes. Food a problem. Tube kept down distention. Enemas relieved bowels but there was a definite "ladder pattern" of the gut by roentgenogram when suction tube was cut off for a day. Feeding progressed in spite of the fact that tube remained in constantly.

November 21.

Hematocrit	51.8 per cent cells
Plasma specific gravity	1.0267
Plasma proteins	6.73 Gm. per cent

Operation: Diagnosis of intestinal obstruction in left upper quadrant. Abscess drained. Peritoneal adhesions released. Inflammatory process still active. General condition good.

After transfusion:

Hematocrit	56.0 per cent cells
Plasma specific gravity	1.0272
Plasma proteins	6.90 Gm. per cent

November 22.

Hematocrit	52.3 per cent cells
Plasma specific gravity	1.0254
Plasma proteins	6.29 Gm. per cent

November 25.

Hematocrit	51.4 per cent cells
Plasma specific gravity	1.0265
Plasma proteins	6.66 Gm. per cent

Since that time, the matter of fluid balance has not been a troublesome problem. Throughout the next few weeks, however, the patient ran a low-grade fever which was felt to be due to a residual pelvic abscess in the region of the appendix.

December 20. Operation: appendectomy.

Upon exploration, the remnants of the appendix were found buried deep in the pelvis within an abscess, the walls of which were firmly adherent to loops of small intestine and the right pelvic wall. This abscess was connected by a sinus tract which led to the site of the original incision. These findings sustained the admitting diagnosis of a ruptured appendix, abscess formation and generalized peritonitis.

DISCUSSION

This case and similar ones studied from day to day, or if need be from hour to hour, have shown us several useful facts.

1. Both hydremia and anhydremia may be accurately judged and objectively followed by these four simple tests.

2. Fluid administration to very ill patients may be of little value if utilization is poor. This is demonstrated here by an increasing hematocrit in spite of an infusion, 3000 cc. of glucose and saline (see Second Emergency Blood Studies). It is just such conditions that cortical extract in conjunction with salt has proved to be efficacious.

3. The ease, speed and accuracy of the method has facilitated many plasma protein determinations.

4. The dangers of too much fluid are often overlooked. The protein level serves as a check on over-treatment.

5. The divergence of hematocrit and plasma protein values (*i. e.*, high hematocrit and low plasma protein level) indicated not only a loss of circulation fluid; but, of *graver* import, a decrease in the proteins. This state is seen in other serious conditions such as perforated ulcers, severe burns, etc. It is the most difficult blood pattern to correct.

6. Increasing peripheral hemoconcentration foretells sooner than blood pressure impending circulatory collapse and thus allows earlier therapy at a time when such measures are more effective.

SUMMARY

1. Methods of measuring and controlling anhydremia in surgical cases are presented.

2. A case report is presented to illustrate their use and interpret the findings in a gravely ill patient.

3. Simultaneous changes in the cell volume and plasma proteins are graphically portrayed.

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